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1.	Your reference	444.79415/001
2.	Patent application number *(The Patent Office will fill in this part)*	0307137.0 27 MAR 2003
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	Santosolve AS Gaustadsalleen 21 N-0349 Oslo Norway
	Patents ADP number *(if you know it)*	8472 834001
	If the applicant is a corporate body, give country/state of incorporation	Norway
4.	Title of the invention	TREATMENT OF PAIN
5.	Name of your agent *(if you have one)*	Frank B. Dehn & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	179 Queen Victoria Street London EC4V 4EL
	Patents ADP number *(if you know it)*	166001

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
GB	0222505.0	27.09.02

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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
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11. I/We request the grant of a patent on the basis of this application.

Signature Frank B Dehn Date 27th March 2003

Frank B Dehn & Co

12. Name and daytime telephone number of person to contact in the United Kingdom

Julian Cockbain
020 7206 0600

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79415.620

Treatment of pain

This invention relates to methods of treatment of subdermal soft tissue pain, in particular chronic pain, using strontium compounds, to the use of strontium compounds for the manufacture of medicaments for use in such methods and to novel strontium-containing pharmaceutical compositions.

Pain is a subjective experience. According to the International Association for the Study of Pain (IASP), pain is an uncomfortable sensory and emotional experience which is associated with tissue damage. The body has its own inhibitory mechanisms which use enkephalins and endorphins to suppress pain impulses. Other bodily mechanisms, in certain situations, act to intensify pain. Because pain is such a complex experience, it is not surprising that it varies from person to person or that, in the same individual, it can vary with time, place and situation.

Pains can generally be categorised as belonging to one of the following types:
nociceptive pain;
neuropathic pain;
psychogenic pain; and
idiopathic pain.

Pain can also be categorised as acute or chronic. By chronic pain is meant pain that has continued or recurred for more than 6 months and which cannot be given a causal therapy. Chronic pain sufferers can be defined as individuals experiencing pain over a prolonged period as a result for example of musculoskeletal disease, accidents (e.g. sports injuries), surgical interventions, soft tissue cancer (e.g. throat cancer), symphysis pubis disfunction, scar tissue, or disease or illness, for example rheumatism.

Throughout the world, there is a rising demand for

treatments to reduce or eliminate chronic or acute pain. Current pain relieving treatments often involve medication or nerve destruction. However there remains a need for methods for relief of chronic and acute pain, especially of subdermal soft tissue pains, e.g. muscular or tendon pain, pain in scar tissue or at surgical incision sites, joint pains, chest pains, back pains, bursal pains (e.g associated with bursitis), etc, and especially methods of treatment which can be carried out by the pain sufferer without medical assistance.

Strontium compounds have been known for topical use in the treatment of itch or irritation of the skin and mucous membranes and of the teeth. Radioactive strontium compounds have also been known for use in the treatment of pain associated with metastatic bone cancers (by virtue of the effects of the radiation emitted by the strontium radionuclides).

However we have now surprisingly found that strontium compounds may also be used effectively to reduce or eliminate sub-dermal soft tissue pain.

Thus viewed from one aspect the invention provides a method of treatment of a human or non-human (e.g. vertebrate, in particular mammalian) subject to combat sub-dermal soft tissue pain (e.g. pain in muscle, joints, sinew, tendon or bursae, in particular muscle pain), in particular chronic or acute pain, especially chronic pain, therein, said method comprising administering to a said subject in need thereof an effective amount of a physiologically tolerable strontium compound.

By sub-dermal pain is meant pain in tissues (e.g. muscles etc) below the dermal or mucosal layer.

Viewed from a further aspect the invention also provides the use of a physiologically tolerable strontium compound for the manufacture of a medicament for use in the treatment of sub-dermal soft tissue pain, particularly chronic pain.

The pain treated according to the invention may for example be associated with diabetes, treatment with cytostatics, chemotherapy, radiotherapy, bursitis, tendonitis, rheumatism, neuropathy, surgical intervention, injury (e.g. sports injury), scar tissue, suspected cardiac infarct, back muscles, soft tissue cancer, symphysis pubis disfunction, and musculoskeletal disease. Typically however it will not be used for treatment of headaches or stomach aches or of the mouth, teeth and gums, although it can if desired.

Dermal application of strontium chloride formulations containing 25% DMSO has now been shown to be effective for reducing pain originating from both dermal and sub-dermal tissues below the application site in patients with a variety of diseases. However, in overweight patients and patients where the pain originates in organs located at a considerable distance below the application site, the amount of strontium reaching its desired site of action may not be sufficient to achieve a significant pain relieving effect. In order to be able to bring sufficient strontium to the affected neurons in such patients, in one embodiment of the invention the strontium is administered transdermally or surgically to a site below the dermal penetration barrier, e.g. in the form of an injection formulation, or in the form of a strontium releasing device.

Injection formulations of strontium can be non-toxic formulations for injection into any site below the dermal penetration barrier, and from which the strontium distributes by passive diffusion to reach the relevant pain receptors or neurons. Examples of the simplest forms of such formulations are strontium chloride in water, or in an isotonic solution. More complex formulations may contain agents like glycofurol and/or DMSO in order to increase diffusion from the site of its deposition. Such formulations may also contain

excipients that cause it to function as a depot at the injection site, releasing the active pharmaceutical ingredient over an extended period of time. Alternatively, an injection formulation could also contain strontium in a form that causes it to accumulate in an organ like the liver, from which the strontium will gradually leak out and eventually reach its intended site of action. Particulate or lipophilic strontium products are examples of formulations that will accumulate in the liver following intravenous injections. Examples of particulate strontium compounds that may be administered include strontium carbonate, strontium phosphate and strontium sulphate as well as liposomes or other fractured liquid crystalline phases containing a dissolved strontium compound, e.g. the chloride, in an internal aqueous phase. Examples of lipophilic strontium compounds include complexes of strontium with lipophilic complexing agents, e.g. those proposed for use as gadolinium complexing agents in the field of MR imaging, e.g. Schering AG (see current promotional material for Schering AG's MRI contrast media). Such lipophilic compounds may also be formulated in particulate products, e.g. micelles, liposomes, or fragmented cubic or hexagonal phases, e.g. in membrane-associated form or dissolved in a lipid phase.

In order to secure a sufficient high strontium concentration to function as a pain-relieving agent in a certain sub-dermal site, simple strontium formulations may also be injected at or near its intended site of action. Examples of such administrations are injections into a sub-dermal organ, e.g. pain affected muscles or ligaments. Such formulations can also be placed into cavities directly in contact with the pain-affected tissue like the bladder in patients with interstitial cystitis, or into the knee of patients with rheumatism in this site. More complex formulation could also

contain strontium in a form that will case it to accumulate in the pain-affected organ. Examples of the latter type of formulations are particulate or lipophilic strontium formulations that will accumulate in the liver following intravenous injections.

The strontium compound used according to the invention is preferably non-radioactive. By "non-radioactive" it is meant herein that the strontium compound is not so enriched in radioactive strontium isotopes as to qualify as a radioactive material for medical purposes. While a minute proportion of the strontium present in the strontium compound may of course be radioactive, the radioactive strontium isotope content of the strontium compound should generally be no more than 1000 times the natural abundance, preferably no more than 100 times, more preferably no more than 5 times. Most preferably the strontium compound contains radioactive strontium isotopes in no more than their natural abundances.

The strontium compound used according to the present invention may be any physiologically tolerable strontium compound capable on administration of acting as a source of strontium ions. Typically, the compound will be an inorganic or organic salt or a complex, e.g. with a chelating agent. Examples of preferred compounds include chloride, nitrate, sulphate, malate, citrate, lactate, oxalate, malate, fumarate, tartrate, malonate, acetate, gluconate, glutaconate, p-aminohippurate, succinate, phosphate, hydrogenphosphate, glycerophosphate, aminocaproate, mandelate, dibenzoyltartrate, stearate, ascorbate, benzoate, 3,4-dimethoxybenzoate, ranelate and methotrexate, and complexes with penicillamine, tyrosine, leucine, etc. Especially preferably the strontium compound, if in salt form, is in the form of the chloride, nitrate, acetate, citrate, lactate or hydrogenphosphate, particularly the chloride, acetate, citrate, lactate or

hydrogenphosphate, more particularly the chloride. However the strontium compound may alternatively be present in the form of a chelate complex, e.g. with a polycarboxylic acid or polyphosphoric acid compound or a cyclic polyether. Examples of appropriate chelating agents are well known in the fields of nuclear medicine and magnetic resonance imaging (see for example the scientific and patent literature from Amersham, Nycomed, Schering, Salutar, Bracco, Sterling Winthrop, Mallinckrodt, etc). The use of linear or cyclic polychelants, such as EDTA, DTPA, EGTA, DTPA-BMA, DOTA, DO3A, 1,2-di(aminoethoxy)ethane-N,N,N',N'-tetraacetic acid, Kryptofix 5 and Kryptofix 222, especially EDTA, is particularly preferred.

It is especially preferred that the strontium compound be administered together with a further analgesic, e.g. aspirin, ibuprofen, or other NSAIDs or COX-2 inhibitors, or as a salt or complex of such an analgesic.

If desired the strontium compound may be administered as a salt or complex of a drug compound having an acid or amine group, preferably such a compound with a physiological effect beneficial to a complaint suffered by the patient, e.g. one effective at treating the underlying condition responsible for the pain. In the case of amino drugs, the resulting strontium compound might typically be a strontium chelate having the amino drug as a counterion. Examples of such drug compounds include nystatin, mesalazin, sulfasalazin, olsalazin, glutaminic acid, repaglinid, pantotenic acid, epoprostenol, iloprost, tirofiban, tranexamic acid, folic acid, furosemide, bumetanide, kanrenoic acid, capopril, enalapril, lisinopril, ramipril, fosinopril, trandolapril, valsartan, telmisartan, pravastatin, fluvastatin, atorvastatin, cerivastatin, sulfadiazin, tretinoin, adapalen, azelaic acid, dinoproston, levotyroxin, lityronin, doxycyclin,

lymecyclin, oxytetracyclin, tetracyclin, ampicillin, amoxicillin, mecillinam, benzylpenicillin, phenoxymethylpenicillin, diclosacillin, clocsacillin, piperacillin, clavulanic acid, tazobactam, cefaleksin, cefalotin, cefoxitin, cefuroksim, ceftazidim, ceftriaxon, aztreonam, meropenem, imipenem, cilastatin, ciprafloksasin, nalidiksinic acid, fusidenic acid, phoscarnet, and zanamivir.

Various of the strontium compounds useful in the present invention are themselves novel, in particular salts or complexes of strontium with cyclooxygenase inhibitors (other than salicylates (e.g. acetyl salicyclic acid) and oxicams (e.g. piroxicam and tenoxicam)), with amino acids, and with multidentate chelating agents (other than EDTA or EGTA) having the ability to form greater than 3, preferably greater than 4 metal coordination bonds.

Examples of appropriate cyclooxygenase inhibitors (e.g. COX1 and/or COX2 inhibitors) include NSAIDs such as amfenac, bendazac, bufexamac, cinmetacin, diclofenac etodolac, felbinac, fenbufen, fenoprofen, fentiazac, flufenamic acid, flunixin, flunoxaprofen, flurbiprofen, furprofen, ibuprofen, indomethacin, ketoprofen, lonazolac, loxoprofen, mefenamic acid, mofezolac, naproxen, and niflumic acid. The strontium salts or complexes can readily be prepared by reacting strontium carbonate with the acid form of these compounds in solution.

Thus viewed from a further aspect the invention provides a salt or complex of strontium and a physiologically tolerable non-salicylate, non-oxicam cyclooxygenase inhibitor.

Viewed from a further aspect the invention also provides a pharmaceutical composition comprising a salt or complex of strontium and a physiologically tolerable non-salicylate, non-oxicam cyclooxygenase inhibitor together with a pharmaceutical carrier or excipient.

Examples of amino acids that may be used to form strontium compounds for use according to the invention include all the natural alpha amino acids, e.g. tyrosine, leucine, lysine, etc. As with the COX inhibitors, the compounds may be prepared in solution using strontium carbonate and the amino acid. However, other strontium salts can also be used, e.g. the chloride, acetate and hydroxide.

Thus viewed from a further aspect the invention provides a salt or complex of strontium and an alpha amino acid.

Viewed from a further aspect the invention also provides a pharmaceutical composition comprising a salt or complex of strontium and an alpha amino acid together with a pharmaceutical carrier or excipient.

Examples of chelating agents which can be used to produce novel strontium compounds for use in the present invention include those with a diethylenetriamine or tetraazacyclododecane backbone carrying at least one oxyacid (e.g. carboxylic or phosphoric acid) metal binding group on the backbone nitrogens, e.g. DTPA, DTPA-bismethylamide, DOTA, DO3A, hydroxypropyl-DO3A, etc. These are well known from the diagnostic imaging contrast agent field and once again the strontium compounds can readily be prepared in solution from strontium carbonate.

Thus viewed from another aspect the invention provides a salt or complex of strontium and a physiologically tolerable diethylenetriamine- or tetraazacyclododecane-backboned chelating agent.

Viewed from a further aspect the invention also provides a pharmaceutical composition comprising a salt or complex of strontium and a physiologically tolerable diethylenetriamine- or tetraazacyclododecane-backboned chelating agent together with a pharmaceutical carrier or excipient.

In general, the strontium compound will be

administered in a pharmaceutical composition comprising at least one physiologically tolerable carrier or excipient. The strontium compound may constitute up to 100% wt of the composition, preferably 0.005 to 50% wt, more preferably 0.05 to 20% wt, especially 0.1 to 10% wt, in particular 0.1 to 3% wt. Conventional pharmaceutical carriers and excipients may be used, e.g. solvents (e.g. water, ethanol, etc), tableting agents, gelling agents, preservatives, emulsifiers, redox agents (e.g. antioxidants), blowing agents, thickeners, viscosity modifiers, pH modifiers, etc.

The strontium compositions for use in the method of the invention may take any convenient administration form depending on the proposed mode of administration (e.g. oral, rectal, nasal, sub-lingual, intramuscular, intravenous, vaginal, transdermal, topical or by inhalation). Thus the compositions may for example be in the form of solutions, dispersions, suspensions, gels, liquid crystalline systems and liquid crystal precursors, emulsions, syrups, tablets, coated tablets, capsules, creams, pastes, unguents, salves, suppositories, sprays, powders, etc. For intravenous and intramuscular administration, solutions are preferred. For transdermal or topical administration, solutions, creams, pastes, unguents, emulsions and gels are preferred. For oral administration, solutions, syrups, tablets, coated tablets and capsules are preferred.

For topical administration, it is especially preferred that the composition contain a skin penetration enhancer and strontium compositions containing such penetration enhancers are novel and form a further aspect of the invention.

Thus viewed from a further aspect the invention provides a pain relieving topical pharmaceutical composition comprising a physiologically tolerable strontium compound, a physiologically tolerable carrier

(e.g. an aqueous solvent, gel, paste emulsion or cream) and a physiologically tolerable skin penetration enhancing agent.

Examples of suitable skin penetration enhancing agents include propylene glycol laurate, propylene glycol monolaurate, propylene glycol monocaprylate, isopropyl myristate, sodium lauryl sulphate, dodecyl pyridinium chloride, oleic acid, propylene glycol, diethylene glycol monoethyl ether, nicotinic acid esters, hydrogenated soya phospholipids, essential oils, alcohols (such as ethanol, isopropanol, n-octanol and decanol), terpenes, N-methyl-2-pyrrolidine, alpha-tocopherol, polyethylene glycol succinate (TPGS), Tween 80 and other surfactants, dimethyl-beta-cyclodextrin and dimethylsulphoxide, especially DMSO.

For administration into the gastrointestinal tract or vagina, it is especially preferred that the composition contain a bioadhesive to promote prolonged contact of the composition with the mucous membranes and strontium compositions containing such bioadhesives are novel and form a further aspect of the invention.

Thus viewed from a still further aspect the invention provides a pain relieving pharmaceutical composition comprising a physiologically tolerable strontium compound and a physiologically tolerable bioadhesive, optionally together with a physiologically tolerable carrier or excipient.

The bioadhesive compositions of the invention preferably contain the strontium compound in micronized form.

Bioadhesive (i.e. mucoadhesive) agents which be used in natural or synthetic, polyanionic, polycationic or neutral, water-soluble or water-insoluble form, but are preferably large (e.g. having a molecular weight of 500 to 3000 kDa. e.g. 1000 to 2000 kDa), water-insoluble cross-linked (e.g. containing 0.05 to 2%, e.g. 0.75 to 1.5% cross-linker by weight of the total polymer, prior

to any hydration), water-swellable polymers capable of forming hydrogen bonds. Preferably the bioadhesives have a mucoadhesive force greater than 100, especially preferably greater than 120, particularly greater than 150, as assessed according to the method of Smart et al. J. Pharm. Pharmacol. 36: p295-299 (1984), expressed as a percent relative to a standard in vitro.

Appropriate bioadhesives include, but are not limited to poly(carboxylic acid-containing) based polymers, such as poly(acrylic, maleic, itaconic, citraconic, hydroxyethyl methacrylic or methaorylic) acid which have strong hydogen-bonding groups, or derivatives thereof such as salts and esters. Alternatively, cellulose derivatives may be used such as methyl cellulose, ethyl cellulose, methylethyl cellulose, hydroxymethyl cellulose, hydroxyethyl ethyl cellulose, carboxymethyl cellulose, hydroxypropylmethyl cellulose or cellulose esters or ethers or derivatives or salts thereof. Other naturally occurring or synthetic polymers may also be used such as gums, e.g. xanthan gum, guar gum, locust bean gum, tragacanth gum, karaya gum, ghatti gum, cholla gum, psillium seed gum and gum arabic; clays such as montmorillonite clays, e.g. Veegum, attapulgite clay; polysaccharides such as dextran, pectin, amylopectin, agar, mannan or polygalactonic acid or starches such as hydroxypropyl starch or carboxymethyl starch; lipophilic formulations containing polysaccharides, e.g. Orabase (Bristol Myers Squibb); carbohydrates, optionally polysubititated with groups such as sulphate, phosphate, sulphonate or phosphonate, e.g. sucrose octasulphate; polypeptides such as casein, gluten, gelatin, fibrin glue; chitosan (lactate or glutamate) or carboxymethyl chitin; glycosaminoglycans such as hyaluronic acid; metal or water soluble salts of alginic acid such as sodium alginate or magnesium alginate; schleroglucan; adhesives containing bismuth oxide or aluminium oxide;

atherocollagen; polyvinyl polymers such as polyvinyl alcohols, polyvinylmethyl ethers, polyvinylpyrrolidone, polycarboxylated vinyl polymers (such as polyacrylic acids as mentioned above); polysiloxanes, polyethers; polyethylene oxides and glycols; polyalkoxides and polyacrylamides and derivatives and salts thereof.

Bioadhesives may also be used which bind to the epithelial cell layer lying below the mucous layer. This allows more specific and longer lasting adhesion due to the slower relative turnover of epithelial cells compared to mucous turnover (days rather than hours). Thus for example, receptor-mediated interactions may be achieved using plant or bacterial lectins, i.e. (glyco) proteins of non-immune origin which bind to polysaccharides or glycoconjugates, which specifically bind to sugar moieties of the epithelial cell membrane. Also so-called "reverse" lectins of mammals in which receptors on the epithelial cell binds to sugars of the agent which is added, may be used. Other bioadhesives (e.g. adhesion or invasion factors (e.g. bacterial adhesins or invasins which bind to integrins) from bacteria or viruses may be used to allow selectively for particular tissues, phenotypes, disorders etc. by binding to only certain epithelial cells.

The above described polymeric bioadhesives may also be cross-linked and may be in the form of copolymers. Preferably poly(acrylic acid) polymers (or copolymers, e.g. with di- or poly-functional allyl ethers or acrylates to make the polymer insoluble), which have preferably been cross-linked, e.g. using a polyalkenyl polyether, may be employed which have a high molecular weight and are thixotropic. Appropriate bioadhesives having this form are available commercially (e.g. from Goodrich) as polycarbophil, e.g. Noveon AA-1, Carbomer (Carbopol), e.g. Carbopol EX165, EX214, 434, 910, 934, 934P, 940, 941, 951, 974P and 1342.

Some of the preferred bioadhesives thus include,

polyacrylic hydrogels, chitosan, polyvinyl alcohol, hydroxypropyl cellulose, hydroxypropyl methyl cellulose, sodium alginate, scleroglucan, xanthan gum, pectin, Orabase and polygalactonic acid.

One particularly effective method of transdermal delivery of strontium ions is iontophoresis. Iontophoretic assemblies containing strontium are novel and form a further aspect of the invention.

Thus viewed from a still further aspect the invention provides an iontophoretic assembly comprising a cathode in electrical contact with a drug reservoir, characterized in that said drug reservoir contains a physiologically tolerable strontium compound.

In the iontophoretic assemblies of the invention, the cathode is preferably a silver electrode and the strontium compound is preferably strontium chloride as the electrode reaction in this way produces insoluble silver chloride. The drug reservoir preferably comprises an aqueous gel containing the strontium compound in dissolved form. The assembly furthermore preferably also comprises a passive skin contact electrode and an electrical power source, e.g. a battery.

The inventors have also surprisingly found that strontium compounds, e.g. of the type described herein, are effective at combatting the pain associated with herpetic infections, in particular herpes zoster (e.g. shingles) and herpes simplex. The strontium compound may be applied topically or given orally or by injection; preferably however it is applied topically. Thus viewed from a further aspect the invention provides the use of a physiologically tolerable strontium compound for the manufacture of a medicament for use in the treatment of herpetic infection. Viewed from a further aspect the invention provides a method of treatment of a human or other mammalian subject experiencing symptoms of herpetic infection, said method

comprising administering to said subject an effective amount of a physiologically tolerable strontium compound.

It has also surprisingly been found that strontium compounds may be used to achieve an antiinflammatory effect both in conditions associated with pain and in conditions not associated with pain, and that in the former case the antiinflammatory effect may beneficially occur at inflammation-affected sites which are distinct from the sites at which the pain is located, e.g. subdermal inflammation affected sites associated with psoriasis, herpetic infection (e.g. herpes simplex or herpes zoster), sun-burn, and acne vulgaris. Examples of conditions which result in inflammation but without necessarily involving an associated pain include polymyositis, dermamyositis, rheumatoid arthritis, osteoarthritis, sports injury, tension and over-use or misuse-induced muscle and tendon inflammation.

Such inflammation-associated conditions may be treated according to the invention by the administration of physiologically tolerable strontium compounds, e.g. by topical or oral administration or other gastrointestinal delivery routes, or more preferably by transdermal administration, for example injection, bolus injection into muscle, and insertion of extended release depot compositions (e.g. into muscle tissue). It is especially preferred to use compositions containing strontium in particulate form, e.g. particles of a strontium compound (optionally together with a matrix material such as for example a polymer), liposomes or other fragmented liquid crystalline forms containing the strontium compound in particulate, or more preferably dissolved form (e.g. in aqueous solution, membrane bound, or in lipid solution) and matrix particles (e.g. water swellable or erodible matrices such as polymer matrices) containing the strontium compound in dispersed form, e.g. microcrystalline or dissolved form.

Thus viewed from a further aspect the invention provides the use of a physiologically tolerable strontium compound for the manufacture of a medicament for use as an antiinflammatory, e.g. in the treatment of a condition associated with pain or of a condition not associated with pain. Viewed from another aspect the invention provides a method of treatment of a human or non-human animal subject to combat inflammation arising from a condition associated with pain or a condition not associated with pain, said method comprising administering to said subject an effective amount of a physiologically tolerable strontium compound.

In a particularly preferred embodiment of these aspects of the invention the inflammation site is preferably sub-dermal and in soft tissue, e.g. in the torso or limbs, especially the muscles and tendons.

The invention is illustrated further in the following non-limiting Examples.

<u>**Example 1**</u>

<u>Composition</u>

A strontium-containing composition was prepared as a 0.1% wt solution of strontium chloride hexahydrate in water.

<u>**Example 2**</u>

<u>Composition</u>

A strontium-containing composition was prepared as a solution in water of 0.1% wt strontium chloride hexahydrate, 0.1% wt of magnesium chloride hexahydrate and 0.1% wt calcium chloride dihydrate.

<u>**Example 3**</u>

<u>Treatment</u>

30 patients with pain around the sternum were asked to complete a questionnaire (a VAS form) to indicate subjectively their level of pain about the sternum. Thereafter the sternum was palpated and a further VAS form was completed to indicate the objective level of pain. The patients were subjected to a spirometric test (MVV) and thermography before treatment according to the invention.

The patients were divided into three groups, one to receive the composition of Example 1, the second to receive the composition of Example 2 and the third to receive a placebo composition (water).

The compositions were applied to the chest (sternum) of the patients by the patients themselves three times per day over a period of two weeks. The liquids were allowed to dry on the skin.

The patients completed daily VAS forms at the treatment times. For a further week the patients wiped a cotton wool pad soaked in the composition evenly over their sternums. The patients were met for weekly control and objective VAS assessment. Following the treatment period, the patients were again subjected to MVV and thermography.

The result of the study was that the patients receiving the strontium compositions had reduced levels of pain. The average VAS value for pain before treatment was 7 to 8 while after strontium treatment it had dropped to 1 to 2. Placebo treatment showed no effect.

In a further case, gargling with a 0.1% wt strontium chloride solution provided significant pain relief to a patient with throat cancer.

Example 4

Production of strontium a (II) complex of ethylenediamine tetraacetic acid (SrEDTA)

A suspension of strontium carbonate (1.0 g, 6.77 mmol) and ethylenediamine tetraacetic acid (1.98 g, 6.77 mmol) in water (25 ml) was stirred at 70°C for 30 minutes. The clear solution was evaporated to dryness and dried in vacuo at ambient temperature. The title compound was isolated as a white crystalline material. Yield 2.79 g (109% calculated as anhydrous product). Melting point above 250°C.

Example 5

Production of the strontium (II) complex of ethylene-bis (oxyethylenenitrilo) tetraacetic acid (SrEGTA)

A suspension of strontium carbonate (1.0 g, 6.77 mmol) and ethylenebis(oxyethylenenitrilo)tetraacetic acid (2.58 g, 6.77 mmol) in water (25 ml) was stirred at 70°C for 6.5 hours. The solution became almost clear. The solution was filtered at room temperature and the filtrate was evaporated to dryness and dried in vacuo at ambient temperature. The title compound was isolated as a white crystalline material. Yield 1.54 g (49%).

Example 6

Production of strontium (II) salicylate

A suspension of strontium carbonate (1.0 g, 6.77 mmol) and salicylic acid (1.87 g, 13.5 mmol) in water (25 ml) was stirred for 4 hours. The solution became pale yellow and almost clear. The solution was filtered at room temperature and the filtrate was evaporated to dryness and dried in vacuo at ambient temperature. The title compound was isolated as a pale red powder. Yield 2.1 g (86%). Melting point above 300°C.

Example 7

Production of the strontium (II) complex of diethylenetriaminepentaacetic acid (SrDTPA)

A suspension of strontium carbonate (1.0 g, 6.77 mmol) and diethylenetriaminepentaacetic acid (2.67 g, 6.77 mmol) in water (25 ml) was stirred at 80°C for 19 hours. The insoluble part was filtered off at room temperature and the filtrate was evaporated to dryness and dried in vacuo at ambient temperature. The title compound was isolated as a white/pale yellow crystalline material. Yield 1.6 g (49%). Melting point approx. 250°C.

The title compound was also prepared in 51% yield using a similar procedure with strontium acetate instead of strontium carbonate.

Example 8

Production of the strontium (II) complex of L-ascorbic acid

A suspension of strontium carbonate (1.0 g, 6.77 mmol) and L-ascorbic acid (2.39 g, 13.5 mmol) in water (25 ml) was stirred at 80°C for seven hours. The mixture became yellow. The mixture was filtered at room temperature, and the filtrate was evaporated to dryness and dried in vacuo at ambient temperature. The title compound was isolated as a yellow powder. Yield 2.50g (78%). Melting point approx. 250°C.

Example 9

Production of the strontium (II) complex of L-ascorbic acid 6-palmitate

A solution of strontium chloride hexahydrate (0.32 g, 1.2 mmol) in water (3 ml) was added to a stirred solution of L-ascorbic acid 6-palmitate (1.0 g, 2.4

mmol) in ethanol/water (100 ml, 50:50 (volume)) at room temperature. The mixture was stirred for 5 minutes and the title compound was isolated by filtration and dried by freeze-drying. Yield 0.514 g (47%). White powder.

Example 10

Production of strontium ibuprofen salt

Ibuprofen (2.59 g, 12.5 mmol) was dissolved in water (100 ml) containing sodium hydroxide (0.503 g, 12.5 mmol). A solution of strontium chloride hexahydrate (1.68 g, 6.3 mmol) in water (5 ml) was added. The mixture was stirred for 10 minutes at room temperature and the title compound was isolated by filtration and dried. Yield 1.30 g (44%). Melting point >300°C.

Example 11

Production of strontium diclofenac salt

Diclofenac (0.35 g, 1.18 mmol) was dissolved in water/ethanol (30 ml, 50:50 (volume)) containing sodium hydroxide (24 mg, 0.59 mmol). A solution of strontium chloride hexahydrate (0.16 g, 0.59 mmol) in water (3 ml) was added. The mixture was stirred for 20 minutes, and the title compound was isolated by filtration and dried. Yield 0.122 g (15%).

Example 12

Preparation of strontium stearate

Stearic acid (2.97 g, 10.4 mmol) was dissolved in water/ethanol (100 ml, 50:50 (volume)) containing sodium hydroxide (0.417 g, 10.4 mmol). The mixture was heated to 70°C and a solution of strontium chloride hexahydrate (1.39 g, 5.2 mmol) in water (3 ml) was added. The title compound was isolated by centrifugation of the formed precipitate. Yield 1.6 g (46%).

Example 13

Production of SrEDTA dimeglumine salt

Strontium EDTA (1 g, 2.65 mmol) (from Example 4) and N-methyl-D-glucamine (1.03g, 529 mmol) were dissolved in water (10 ml) and stirred at 70°C for 30 minutes. The mixture was filtered and the filtrate was evaporated to dryness and dried in vacuo at ambient temperature. The title compound was isolated as white crystalline material. Yield 0.722 g (36%).

Example 14

Production of strontium benzoate

Strontium carbonate (1.0 g, 6.77 mmol) and benzoic acid (1.65 g, 13.5 mmol) in water (30 ml) were stirred for 4 hours at 70°C. The mixture was filtered and the fitrate was evaporated to dryness and dried in vacuo at ambient temperature. The title compound was isolated. Yield 1.8 g (81%).

Example 15

Production of strontium glutarate

Strontium carbonate (1.0 g, 6.77 mmol) and glutaric acid (0.89 g, 6.77 mmol) in water (30 ml) were stirred over night at 70°C. The mixture was filtered and the filtrate was evaporated to dryness and dried in vaccuo at ambient temperature. The title compound was isolated. Yield 1.23 g (83%).

Example 16

Production of strontium alanine salt

Strontium hydroxide octahydrate (1.0 g, 3.79 mmol) and L-alanine (0.67 g, 7.52 mmol) in water (30 ml) were stirred for 4 hours at room temperature. The mixture

was filtered and the filtrate was evaporated to dryness and dried in vaccuo at ambient temperature. Yield 0.81 g (63%).

<u>Example 17</u>
<u>Production of strontium hippurate</u>

Strontium carbonate (0.5 g, 3.39 mmol) and hippuric acid (1.215 g, 6.77 mmol) in water (30 ml) were stirred at 70°C for 5 hours. The mixture was filtered and the filtrate was evaporated to dryness and dried in vacuo at ambient temperature. Yield 1.25 g (83%).

<u>Example 18</u>
<u>Production of a strontium chelate with 1,2-di(2-amino-ethoxy)ethane-N,N,N',N'-tetraacetic acid</u>

Strontium carbonate (1.0 g, 6.77 mmol) and 1,2-di(2-amino-ethoxy)ethane-N,N,N',N'-tetraacetic acid (2.58 g, 6.77 mmol) in water (30 ml) were stirred at 85°C for 48 hours. The mixture was evaporated and the title compound dried in vaccuo at ambient temperature. Yield 2.55 g (81%).

The compounds of Examples 4 to 18 may be formulated for administration in any convenient form (e.g. gels, creams, solutions, tablets, etc) using conventional pharmaceutical carriers and excipients.

<u>Example 19</u>
<u>Skin penetration composition</u>

A strontium-containing composition was prepared by dissolving 40 g strontium chloride hexahydrate in 1000 ml solvent. The composition of the solvent was:
50% (volume) distilled water
25% (volume) Tetraglycol® (glucofurol)

25% (volume) DMSO

Two patients with Bechterev disease had been using non-steroidal anti-inflammatory drugs and opioids without pain relief in the iliosacral joints. The composition of this Example was administered dermally at the iliosacral joints, two - three times daily. Both patients observed a complete relief of pain.

Example 20
Solution for injection

Strontium EDTA dimeglumine salt (20 mg) from Example 13 was dissolved in a 0.9% sterile aqueous solution (10 ml) and filled in a 10 ml vial (injection vial with rubber stopper). The solution was sterilised by autoclaving. The solution contained 0.2 mg strontium per ml.

Example 21
Hydrogel containing ibuprofen, strontium ascorbate and skin penetration enhancer

Strontium ascorbate (900 mg) from Example 8 and sodium lauryl sulphate (450 mg) were mixed into Ibux gel 5% (produced by Weifa AS, Oslo, Norway) using a mortar and pestle. (Ibux gel contains 5% ibuprofen in a hydrogel comprising hydroxyethylcellulose, benzylalcohol, isopropanol, sodium hydroxyl and purified water). The resulting gel contained 1.2% wt strontium.

Example 22
Hydrogel comprising ibuprofen and strontium chloride

Strontium chloride hexahydrate (0.8 g) was mixed into Ibux gel 5% (19.2 g) using a mortar and pestle.

Example 23

Mucoadhesive hydrogel comprising ibuprofen and strontium chloride

Polyacrylic acid 5100 sodium salt (Fluka 81132) (0.21 g) was mixed into a hydrogel comprising ibuprofen and strontium (see Example 22) (7.0 g) using a mortar and pestle.

Example 24
Mucoadhesive hydrogel comprising ibuprofen and strontium chloride

Strontium chloride hexahydrate (1.5 g) and chitosan malate (203-490-14SM from FMC Biopolymers, Drammen, Norway) (0.75 g) were mixed into Ibux gel 5% (12.75 g). The resulting mucoadhesive gel contained 3.3% wt strontium and 5% wt ibuprofen.

Example 25
Cream containing strontium chloride

Strontium chloride hexahydrate (1.2 g) was mixed into Unguentum Merck (13.8 g) using a mortar and pestle. The cream contained 2.6% wt strontium in the form of strontium chloride.

Example 26
Cream containing strontium chloride and a skin penetration enhancer

Strontium chloride hexahydrate (1.2 g) and sodium lauryl sulphate (0.3 g) were mixed into Unguentum Merck (13.5 g) using a mortar and pestle. The cream contained 2.6% wt strontium in the form of strontium chloride.

Example 27
Cream containing lidocaine and strontium diclofenac salt

Strontium diclofenac (40 mg) from Example 11 was mixed into Xylocain® 5% cream (Astra Zeneca AS, Oslo, Norway) using a mortar and pestle. (100 g Xylocain® 5% cream contains 5 g lidocaine in coconut oil 13.8 g, polyoxyethylene ester 4.5 g, carboxypolymethylene 1 g, sodium hydroxide 6.5 g and purified water 69 g). The cream contained 5% wt lidocaine and 40 mg/g strontium diclofenac.

Example 28

Ointment containing hydrocortisone and strontium stearate

Strontium stearate (60 mg) from Example 12 was mixed into Hydrokortison 1% ointment (Galderma Nordic AB) using a mortar and pestle (Hydrokortison 1% ointment contains 1% hydrocortisone, propyleneglycol, liquid paraffin, cetylalcohol and Vaseline®). The resulting ointment contained 1% wt hydrocortisone and 3% wt strontium stearate.

Example 29

Mucoadhesive formulation containing strontium ibuprofen

Strontium ibuprofen (0.5 g) from Example 10 was mixed into Orabase® paste (Squibb AB, Lidingö, Sweden) (14.5 g) using a mortar and pestle. Orabase® contains gelatin, pectin, sodium carboxymethhylcellulose, polyethylene and liquid paraffin. The resulting formulation contained 3.3% wt strontium ibuprofen and is useful for treatment of pain in the mouth or other mucosal body surfaces.

Example 30

Clinical testing of the composition of Example 19

A 35 year old woman was involved in a car accident seven

years earlier and had developed severe pain in the neck and shoulders. The patient had used non-steroidal anti-inflammatory drugs for a long time without significant effect. She had not slept continuously any night since the accident.

The patient tried the composition of Example 19 by administering topically to the areas of pain. She claimed a pain relieving effect after one minute and had no or very little pain for the following 2 to 3 days. After administration of the composition of Example 13 she was able to sleep for about 10 hours each of the next two nights.

Example 31

Clinical testing of the composition of Example 19

Nine boxers with pain in the face and/or fingers have tested out the effect of the composition of Example 19. The composition was administered directly onto the painful area. An immediate relief of pain was observed for all painful areas by these boxers. The pain reduction was present for a long time.

Four boxers with pain in the nose and eye area tested the effects of a composition which was a 2% wt formulation of strontium chloride hexahydrate in the same solvent as in Example 19 (i.e. 50% of the strontium concentration in Example 19). This formulation also showed good clinical effects both with regard to pain relief and reduction of swelling of the painful area.

Example 32

Clinical testing of composition from Example 19

A patient with pain in the pelvic area as a result of lack of ligaments during pregnancy had tried non-

steroidal anti-inflammatory drug treatment for some time without any effect.

The topical formulation of Example 19 was applied and resulted in an immediate reduction in pain. The pain relief effect extended for about six hours per application.

Example 33

Clinical testing of composition from Example 19

Two patients with herpes simplex infection in the mouth area had previously used antiviral cream (Zovirax® (acylovir)) with moderate effect. The effect of the antiviral treatment was an improvement in the progress of the disease, but lesions were present for seven to ten days (as without treatment).

These two patients have now used the composition of Example 19 during eight different outbreaks of lesions. Local administration of the composition totally stopped the development of the lesions and dried out lesions which had formed.

Example 34

Preparation of nanoparticles comprising strontium EDTA

Poly(D,L-lactide-co-glycolide) (50:50) (M_w 20000) (100 mg) is dissolved in dichloromethane (10 mg). An aqueous solution of poly(vinyl alcohol) (PVA) (M_w 15000) (2.5%) (3 ml) containing strontium EDTA (10 mg) (from Example 4) is added and the mixture is homogenised for 10 minutes. An aqueous solution of PVA (1.5%) (25 ml) is added and the mixture is evaporated down. The resulting nanoparticles are washed with water and freeze dried.

Example 35

Preparation of suspension of nanoparticles comprising strontium EDTA for injection

Nanoparticles comprising strontium EDTA (100 mg) from Example 34 are dispersed in an isotonic aqueous solution of glucose (5 ml). The suspension contains 2 mg strontium EDTA per ml.

Example 36

Lipid emulsion of strontium stearate for injection

Strontium stearate (5 g) (from Example 12) is added to a lipid emulsion (Intralipid® 300 mg lipid per ml from Pharmacia and Upjohn) (500 ml). The mixture is homogenized for 1 hour and filled into 10 ml vials. Each vial contains 100 mg strontium stearate.

Example 37

Lipid formulation of strontium ibuprofen for intramuscular injection (sustained release)

Strontium ibuprofen salt (50 mg) (from Example 10) is added to saturated triglyceride (1 ml). The mixture is homogenized for 2 minutes.

Example 38

Preparation of suspension of liposomes containing strontium chloride

Soy bean lecithin (0.8 g) is dissolved in ethanol (8 ml). The mixture is rotary evaporated into a thin film at 55°C. The lipid film is rehydrated with an aqueous solution of strontium chloride (50 mg in 6 ml) by shaking at 60°C for 20 minutes followed by sonication and extrusion through 100 nm polycarbonate filter. The extrusion is repeated 10 times. The mixture is filled

into a 10 ml vial.

Claims:

1. A method of treatment of a human or non-human subject to combat sub-dermal soft tissue pain therein, said method comprising administering to a said subject in need thereof an effective amount of a physiologically tolerable strontium compound.

2. A method as claimed in claim 1 wherein said strontium compound is administered to the surface of the skin.

3. A method as claimed in either of claims 1 and 2 wherein said soft tissue is muscle.

4. The use of a physiologically tolerable strontium compound for the manufacture of a medicament for use in the treatment of sub-dermal soft tissue pain.

5. A pain relieving topical pharmaceutical composition comprising a physiologically tolerable strontium compound, a physiologically tolerable carrier and a physiologically tolerable skin penetration enhancing agent.

6. A composition as claimed in claim 5 wherein said skin penetration enhancing agent is dimethylsulphoxide.

7. A pain relieving pharmaceutical composition comprising a physiologically tolerable strontium compound and a physiologically tolerable bioadhesive, optionally together with a physiologically tolerable carrier or excipient.

8. A composition as claimed in any one of claims 5 to 7 wherein said strontium compound is strontium chloride or strontium nitrate.

9. An iontophoretic assembly comprising a cathode in electrical contact with a drug reservoir, characterized in that said drug reservoir contains a physiologically tolerable strontium compound.

10. A salt or complex of strontium and a physiologically tolerable non-salicylate, non-oxicam cyclooxygenase inhibitor.

11. A pharmaceutical composition comprising a salt or complex of strontium and a physiologically tolerable non-salicylate, non-oxicam cyclooxygenase inhibitor together with a pharmaceutical carrier or excipient.

12. A salt or complex of strontium and an alpha amino acid.

13. A pharmaceutical composition comprising a salt or complex of strontium and an alpha amino acid together with a pharmaceutical carrier or excipient.

14. A salt or complex of strontium and a physiologically tolerable diethylenetriamine- or tetraazacyclododecane-backboned chelating agent.

15. A pharmaceutical composition comprising a salt or complex of strontium and a physiologically tolerable diethylenetriamine- or tetraazacyclododecane-backboned chelating agent together with a pharmaceutical carrier or excipient.

16. The use of a physiologically tolerable strontium compound for the manufacture of a medicament for use in the treatment of herpetic infection.

17. A method of treatment of a human or other mammalian subject experiencing symptoms of herpetic infection,

said method comprising administering to said subject an effective amount of a physiologically tolerable strontium compound.